

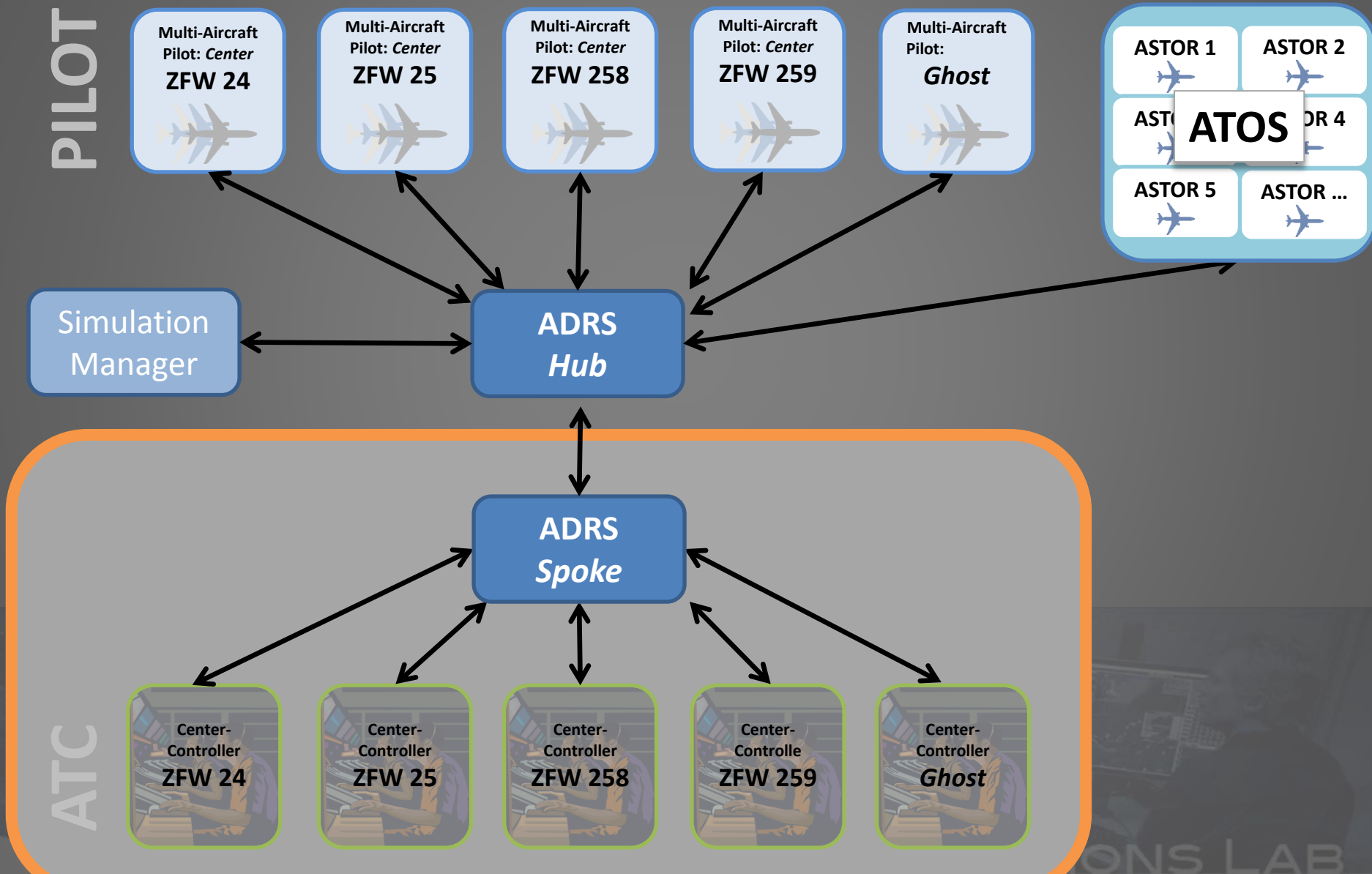


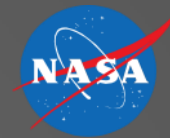
# Tuesday (01/10/2012)

## Briefings

08:30	Intro and MACS Overview
09:40	Break
10:00	MACS/ADRS simulation architecture and integration with ATOS and TMA
11:00	Using MACS to simulate aircraft operations <i>Simulation Manager and Flight Deck Stations</i>
12:00	Lunch
1:00	Basic Air Traffic Control Operations.
1:30	Using MACS to simulate near-term air traffic control operations. <i>Focus ATD-1, Center/TRACON workstations, Scheduling, CMS</i>
2:45	Break
3:00	Using MACS to simulate far-term automated air traffic control operations. <i>Focus on Separation Assurance</i>
3:45	Developing MACS Software
4:30	End of day

# Separation Assurance/Function allocation simulation components. MACS pilot and controller stations for en route, ATOS (in preparation)

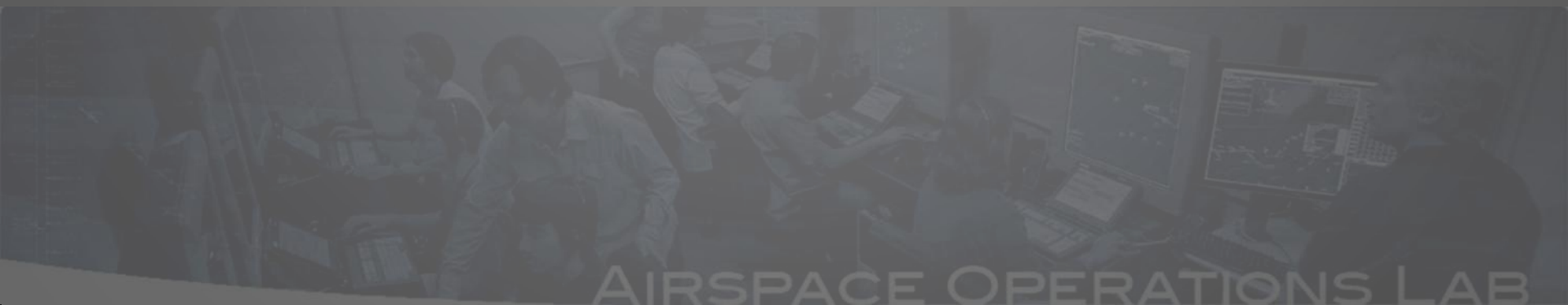


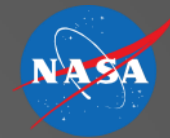


# Using MACS to simulate far-term automated air traffic control operations.

## *Focus on Separation Assurance*

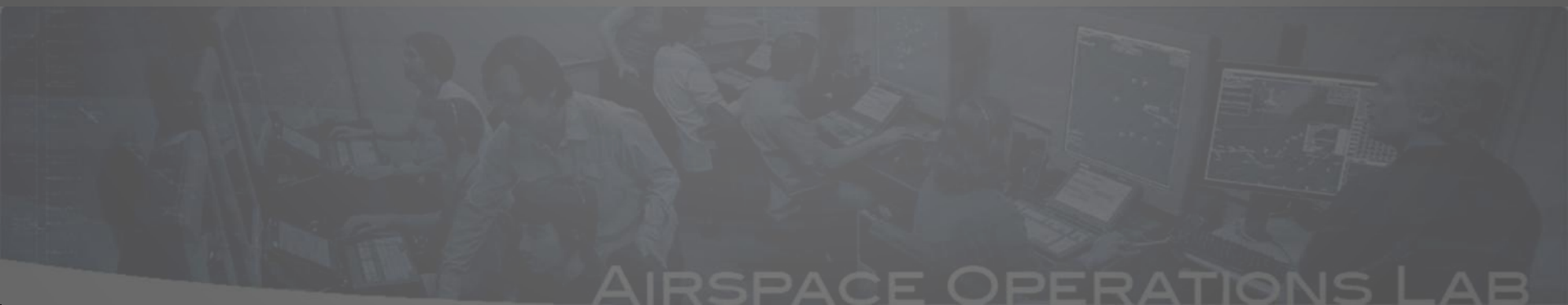
Tom Prevot





# Overview

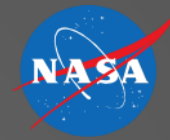
- Enroute controller stations in the mid-term
- Automated enroute controller stations in the far-term



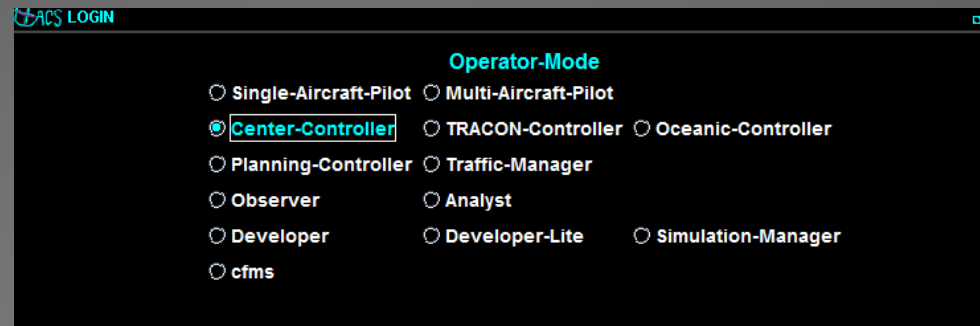
# Air Traffic Control



# En Route Controller Positions

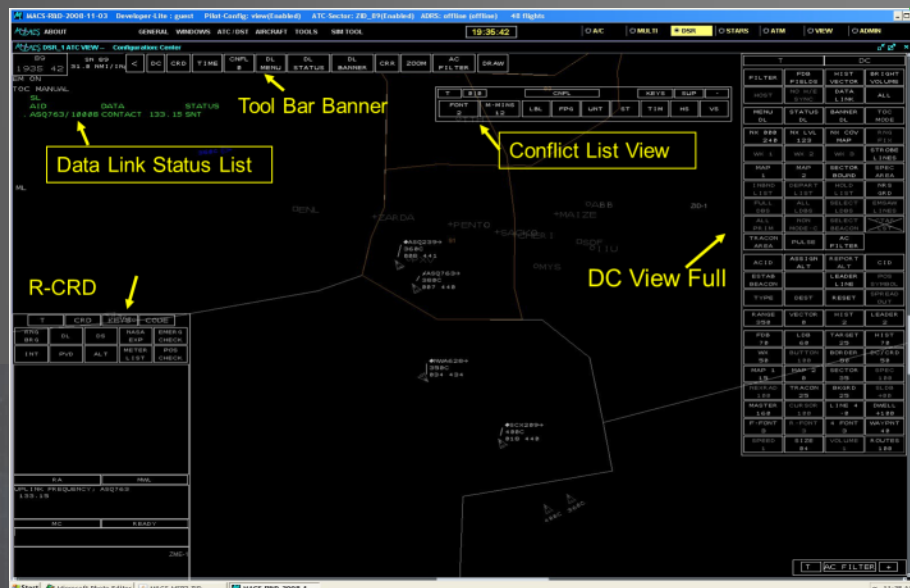


## Operator-Mode: Center-Controller



## Primary Display: DSR View

DSR: Display System Replacement



## Most Relevant Setup Files:

- ATC DST Configuration
- ATC DST Sector Configuration
- DSR Data Tag Rules Setup
- DSR Plan View Setup
- DSR Sector Plan View Setup
- DSR Timeline Setup



# En-Route: R-side & D-side DSR

MACS R&D-2008-11-03 Developer-Lite : guest Pilot-Config: view(Enabled) ATC Sector: ZID\_B9(Enabled) ADRS: offline (offline) 48 flights

MACS ABOUT GENERAL WINDOWS ATC/DST AIRCRAFT TOOLS SIM TOOL 19:35:42 [A/C] [MULTI] [DSR] [STARS] [ATM] [VIEW] [ADMIN]

MACS DSR\_1 ATC VIEW -- Configuration: Center

89 SN 89 1935 42 31.0 NM/IN. < DC CRD TIME CNFL DL MENU DL STATUS DL BANNER CRR ZOOM AC FILTER DRAW

EM ON TOC MANUAL SL AID DATA STATUS ASQ763/10008 CONTACT 133.15 SNT

ML DENL +ZARDA +PENTO +SACKO +MAIZE +OABB ZID-1

ASQ239→ 360C 008 441  
ASQ763→ 360C 007 440  
NWA628→ 350C 034 434  
SCX289→ 480C 010 440  
480C 360C

R-CRD

Tool Bar Banner

Data Link Status List

Conflict List View

DC View Full

T		DC	
FILTER	FDB FIELDS	HIST VECTOR	BRIGHT VOLUME
HOST	NO H/E SYNC	DATA LINK	ALL
MENU DL	STATUS DL	BANNER DL	TOC MODE
NX 000 240	NX LVL 123	NX COV MAP	RNG FIX
WX 1	WX 2	WX 3	STROBE LINES
MAP 1	MAP 2	SECTOR BOUND	SPEC AREA
INBND LIST	DEPART LIST	HOLD LIST	NRS GRD
FULL DBS	ALL LDBS	SELECT LDBS	EMSAW LINES
ALL PRIM	NON MODE-C	SELECT BEACON	CTAS LST
TRACON AREA	PULSE	AC FILTER	
ACID	ASSIGN ALT	REPORT ALT	CID
ESTAB BEACON		LEADER LINE	POS SYMBOL
TYPE	DEST	RESET	SPREAD OUT
RANGE 350	VECTOR 0	HIST 2	LEADER 2
FDB 70	LDB 60	TARGET 25	HIST 70
WX 50	BUTTON 100	BORDER 50	DC7/CRD 50
MAP 1 15	MAP 2 0	SECTOR 35	SPEC 100
NEXRAD 100	TRACON 25	BKGRD 25	SLDB +00
MASTER 160	CURSOR 100	LINE 4 -0	DWELL +100
F-FONT 3	R-FONT 3	4 FONT 3	WAYPNT 40
SPEED 1	SIZE 04	VOLUME 1	ROUTES 100

RA MWL

UPLINK FREQUENCY: ASQ763 133.15

MC READY

ZME-1

T AC FILTER +



# Mid-Term Controller Tools

- 4D trajectory generation for flight plan routing, scheduling, reported FMS trajectories, ADS-B reported state and flight control system targets
- Arrival scheduler and timelines
- Medium-term Conflict detection
- Trial planning and speed advisory functions for metering support
- Automation for automatic transfer of communication and RTA uplinks
- Multi-layered rapid feedback conflict probing
- Weather penetration probe
- Data comm. integration
- Fully automated, semi-automated, manual operations
- AAC Auto-Resolver with Weather avoidance
- Most functions are configured via the ATC DST Configuration



# Conflict Probe FDB

## Flight Data Block Conflict Information



## Font Color Coding for Time-to-Conflict values

- **Red Font:** time-to-loss of separation is < 3 minutes
- **Yellow Font:** time-to-loss of separation is > 3 minutes  $\leq$  5 minutes
- **White Font:** time-to-loss of separation is > 5 minutes but < 12 minutes

# Trial Planning

- Trial Plan Options

- Single or Multi-Aircraft
- Typed Commands into DSR CRD
  - FF- selects aircraft for group trial planning
  - TT- opens basic route trial plan
  - TA- opens an altitude trial plan
  - TR- opens a more specified route trial plan

## Multiple Aircraft Trial Plan- FF



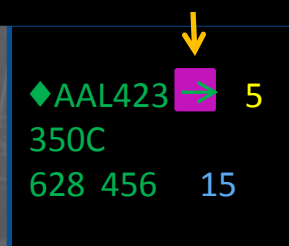
- Interactive Flight Data Block (FDB)

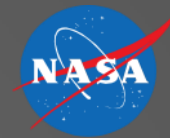
- Arrow next to the aircraft call sign- opens basic route trial plan
- Same arrow (but magenta-colored)- to review a suggested trial plan
- Altitude line of the FDB- opens an altitude trial plan
- Conflict number to start a automated trial plan resolution to solve for the predicted traffic conflict
- Weather number to start a trial plan to solve for the predicted weather penetration

- Drag and Drop Route Line

- Lat/Long
- Waypoint

## FDB Trial Plan Portal





# Air/Ground Data Communication

## Key Uplink Capabilities

- Trajectory information [or parameters] and trajectory constraints (route modification uplinks, altitudes, profile speeds, required times of arrival)
- transfer of communication (i.e. frequency changes)
- free text (encode anything in text format)
- responses to aircraft initiated requests

## Key Downlink capabilities

- Responses (wilco, reject)
- Free text (encode anything in text format)
- Requested trajectory changes

## Broadcast/ downlink capabilities

- Aircraft state and velocities
- Short term intent and flight modes (i.e. flight control system settings )
- FMS trajectory reports
- FMS inputs (e.g. speed profile, weight)

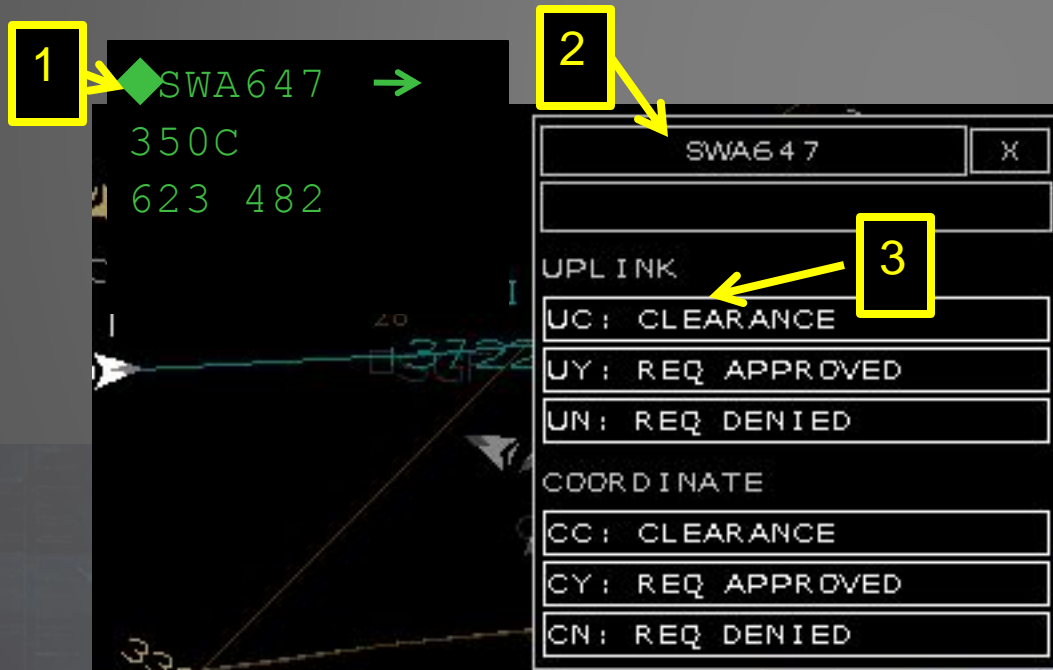
# Data Comm: Mixed Equipage

## Equipped Data Comm Clearance



### Uplink Clearance to Aircraft (Point and Click)

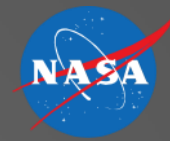
1. Pick on data link portal (filled triangle)
2. Drop down box appears next to FDB
3. Pick on UC: Clearance to uplink to aircraft



### Uplink Clearance via Keyboard

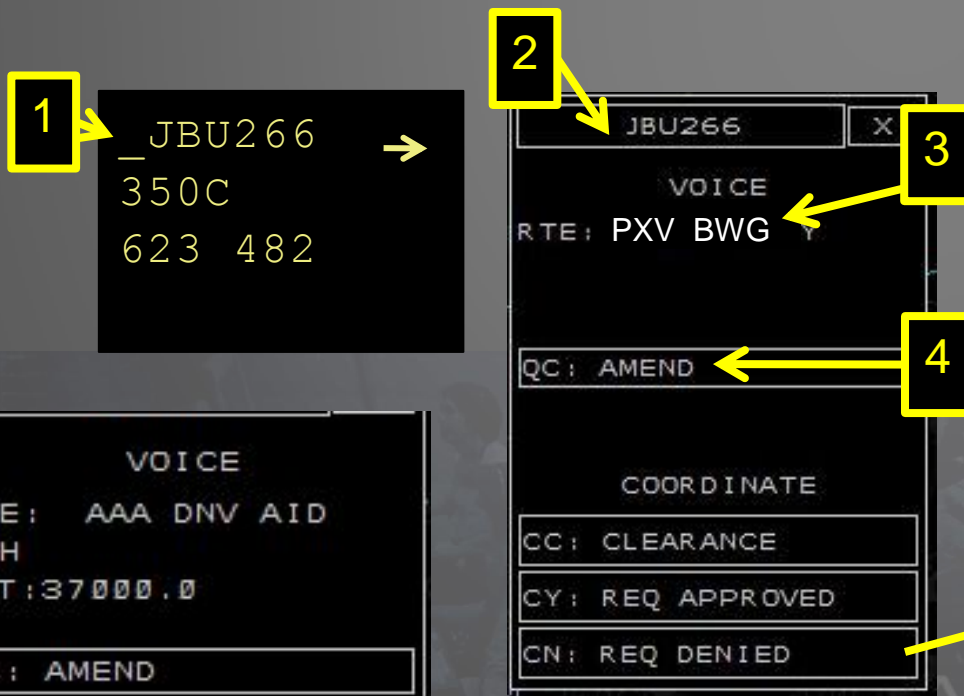
- Type UC [CID] ENTER

# Data Comm: Mixed Equipage Un-Equipped Verbal Clearance



## Issue TP or CC Clearance to Aircraft (Point and Click)



1. Pick on data link portal (underscore symbol)
2. Drop down box appears next to FDB
3. Voice clearance appears, issue to aircraft Direct PXV, BWG rest of route unchanged
4. Pick on QC: Amend in Automation (HOST)









# Data Comm FDB Information

 AAL207 → 350C 623 482	_AAL207 → 350C 623 482	 AAL207 → 350C 623 482	 AAL207  350C 623 482
---	------------------------------	---	---

status the following data link status symbols are found in the flight data block (left of the call sign):

symbols  : eligibility    : no eligibility  : TOC in progress    ↑ : uplink in progress

 : coordination request (right of callsign)

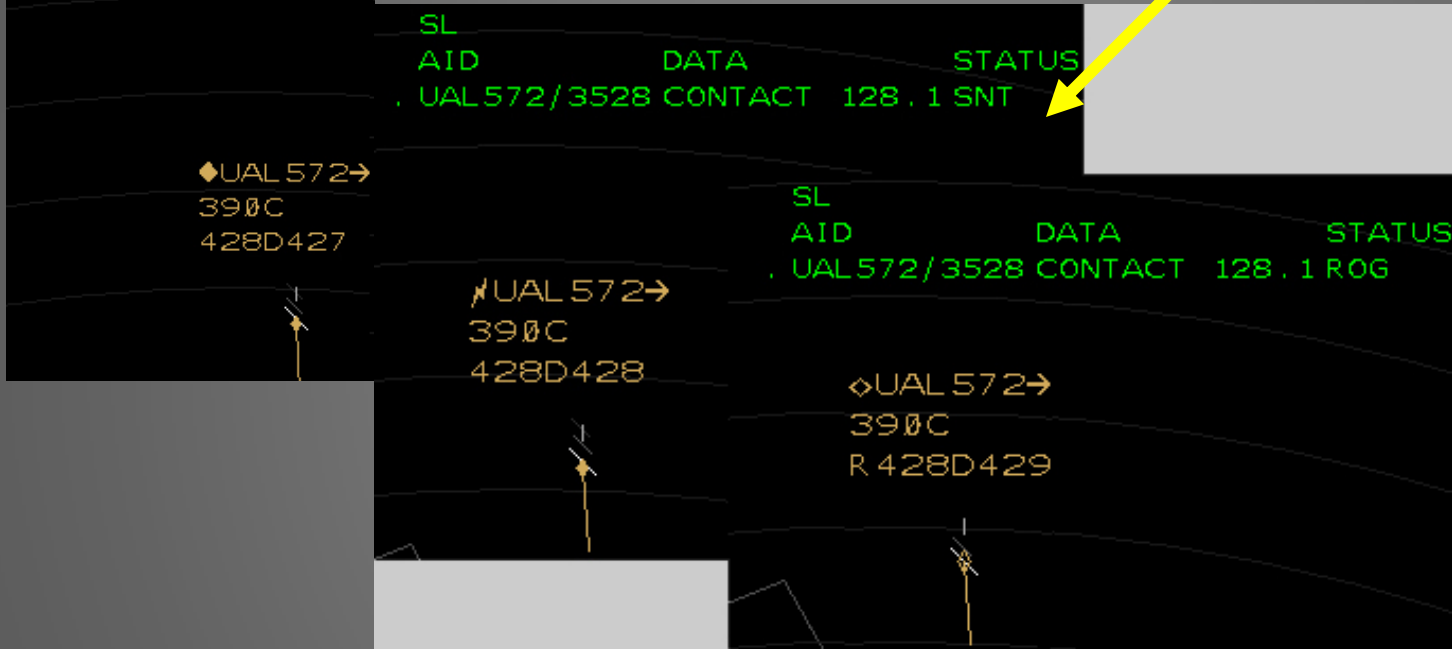
- A filled diamond () indicates that the sector has “eligibility”, and can send and receive messages to the aircraft. Data link eligibility usually accompanies track control, but the transfer mechanism is separate.
- An unfilled diamond () indicates that the sector does not have “eligibility” (i.e., cannot communicate with this aircraft via CPDLC).
- A lightning bolt () indicates that a transfer of communication (and transfer of eligibility) is in progress.
- An up arrow () indicates that a message has been “uplinked” from the controller to the aircraft. The uplink may be a clearance, frequency, or text message.
- A magenta arrow () indicates a coordination request which is a clearance request sent to the CPDLC eligible controller from another ground position or MSP.

# Sample Data Comm Transfer of Communication (Air-to-Ground)



SL  
AID DATA STATUS

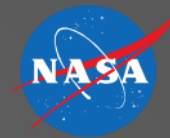
TOC View for frequency hand-off from sending sector:



TOC View for accepting hand-off  
frequency change from receiving sector:







Multi Aircraft Control System (MACS)

# **AIR TRAFFIC CONTROL OPERATIONS FAR-TERM / 2030**

30, 40, or 50 aircraft are allowed in Airspace “sectors” at any given time  
1 or 2 Air Traffic Controllers per sector possible  
Video shows 8 controllers handling ~300 aircraft

AIRSPACE OPERATIONS LAB

# Air Traffic Control in 2030 ...



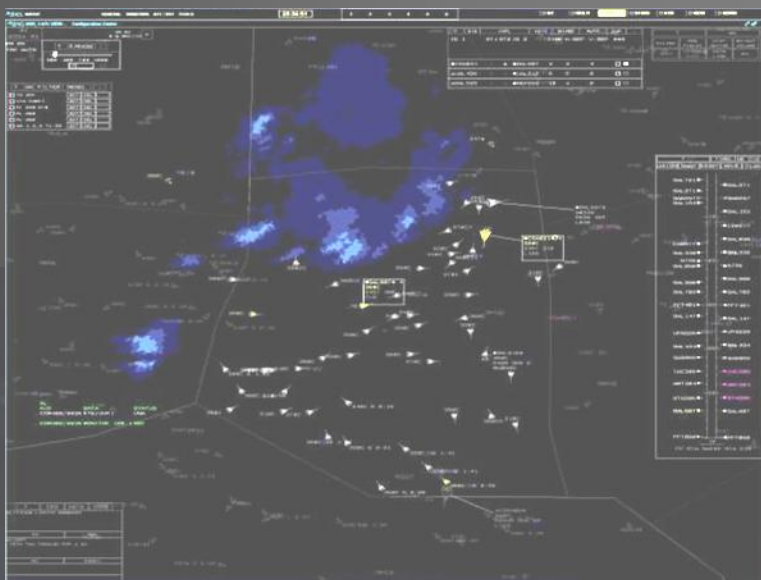
# Function Allocation used in Study

## Automation

- Detect Separation and weather Conflicts
- Resolve trajectory-based conflicts (if within tolerances)
- Resolve all time-critical traffic conflicts
- Alert controller to urgent problems
- Provide trajectory planning assistance
- Use data comm. to communicate

## Controller

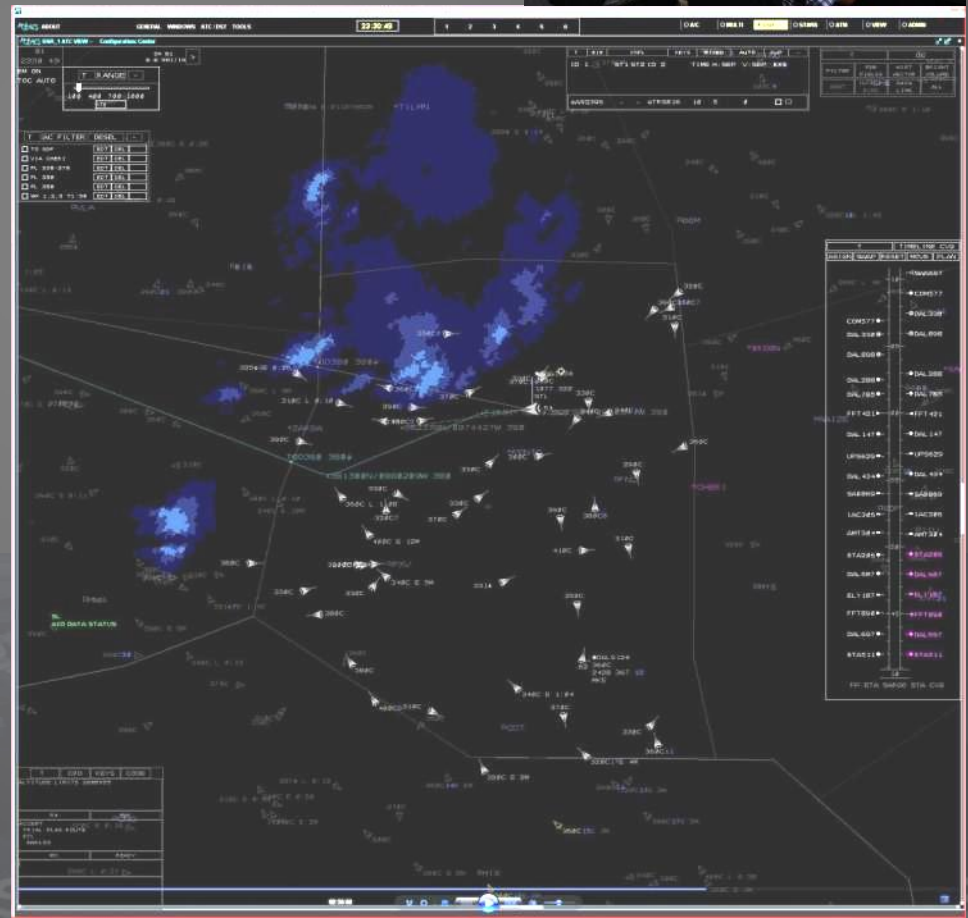
- Supervise the automation
- Resolve trajectory conflicts flagged by the automation
- Monitor and maintain schedule compliance
- Implement weather reroutes with automation support
- Place aircraft back on trajectory following automated tactical maneuvers



# Prototype System

# Integrated controller workstation with

- Trajectory planning
- Data communication
- Conflict probing
- Trajectory-based conflict resolution
- Short-term conflict alert and resolution
- Weather avoidance
- Scheduling and time-based metering



# Trajectory-based CD&R

T	000	CNFL	KEYS	MIXED	AUTO	SUP	-		
FONT	M-MINS	A-MINS	LBL	UNT	ST	TIM	HS	VS	BXS
2	10	10							
ID 1	ST1	ST2	ID 2	TIME	H-SEP	V-SEP	BXS		
◆SAS489	↓	↓	↑TAS573	1	4	8	<input type="checkbox"/>	<input type="checkbox"/>	
◆AFR689	-	↓	◆SAS489	4	5	8	<input type="checkbox"/>	<input type="checkbox"/>	
◆AFR689	-	↓	↑TAS573	9	2	0	<input type="checkbox"/>	<input type="checkbox"/>	
○AMC931	-	-	○SVA894	9	5	0	<input type="checkbox"/>	<input type="checkbox"/>	
○ACA277	-	↓	○ACA471	9	0	9	<input type="checkbox"/>	<input type="checkbox"/>	

Link Status Symbols

Yellow

Cyan

Green

Blank

## Conflict Selection Boxes

-Pick this box if you want to mark that conflict for review

## Data Link Status Symbols

## Separation Assurance Resolution Status Boxes

- ☐ Yellow: controller assistance needed
- ☐ Cyan: trial plan trajectory present
- ☐ Green: conflict solved, uplink sent
- ☐ Blank: no action has been taken yet
- ☐ White: automatic resolution started

Automation status indication integrated in relevant places on the displays  
(e.g. resolution, conformance data link status)





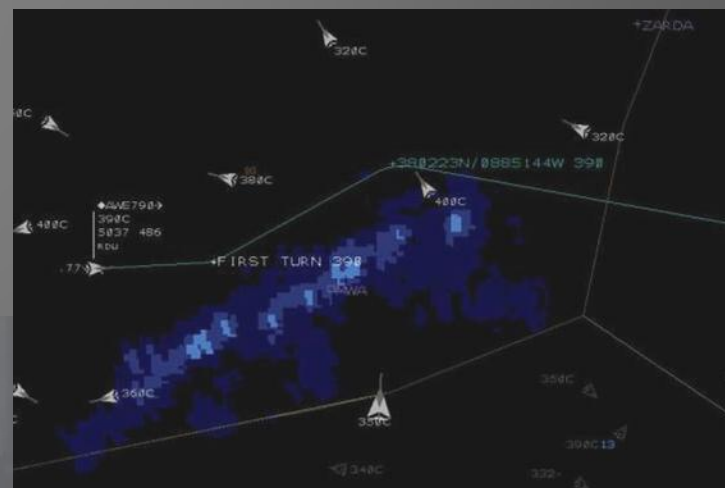
# Tactical Short-Term CD&R

Vectoring solutions are highlighted in data tag and sent by the automation

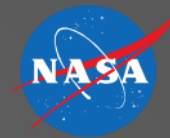


# Improvements

- Automation
  - Altitude fly-out menu with real-time conflict feedback
  - Free-track trajectory automation
  - Semi-automated weather avoidance
- Human Automation Interaction and Procedures







# Questions?

Tom Prevot

